Next Generation Space Telescope

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The Next Generation Space Telescope (NGST) is a component of the origins program. The NGST will assist in determining the origins of galaxies, stars, and planetary systems. The baseline concept for the NGST is an 8-m-diameter, filled aperture telescope with diffraction limited performance at wavelengths between 0.5 and 5.0 µm, operating in a high-Earth orbit. The operating temperature of the optics will be 30 Kelvin. The launch vehicle is to be an Atlas IIAS with a 12-ft ID by 32-ft tapered faring. The weight of the optical telescope assembly is not to exceed 2,200 lb and the costs are not to exceed $100 million.

Two industrial teams and a Government team, including Goddard Space Flight Center, Marshall, and the Jet Propulsion Laboratory personnel, have each prepared preliminary designs and feasibility studies for NGST. Estimates of predicted performance, costs, weight, and launch volume have been included. MSFC members of the Government team were responsible for the optical telescope assembly. Key elements of this design include:

- Optical design: A 4 mirror, centered design that achieves diffraction limited performance at a wavelength of 2.0 µm over a 4 by 4 arc min field, has been prepared. The primary and secondary mirrors are much like a conventional Cassegrainian. The tertiary is a concave asphere located behind the primary. The quaternary is plano and is designed as a deformable mirror allowing wavefront correction.
- Structural design: An articulated design is required to fit the telescope assembly within the launch vehicle shroud. The primary mirror design provides an array of eight folding panels around a central section. Four of the panels fold forward toward the secondary mirror location, and four of the panels fold backwards toward the instrument package for launch. All eight panels are deployed and locked in place on orbit. The secondary mirror is positioned near the vertex of the primary mirror for launch and is deployed in the required position on orbit by an expanding structure.

Primary Mirror Design: The principal elements in the primary mirror design are:
- The mechanisms that deploy and lock the segments in place;
- The mechanisms that phase and align the segments with the central segment; and
- The mirror substrate design itself, including material selection, method of support, and the fabrication approach.

The weight allocation for the primary mirror requires its areal density to be in the range of 5 to 7 kg/m^2.

While each of these areas presents formidable tasks, the design, fabrication, and testing of the primary mirror are believed to present the greatest challenge. The magnitude of this challenge is best understood when the requirements for the NGST primary mirror are compared to the Hubble Space Telescope (HST) primary mirror. The area of the NGST primary mirror is more than an order of magnitude larger than HST, while its areal density is 5 to 7 kg/m^2 compared to approximately 160 kg/m^2 for HST. Furthermore, the HST primary is a stiff monolith operating at near room temperature while the NGST primary is an articulated ensemble of compliant panels, deployed on orbit, operating at a cryogenic temperature.

The design, choice of materials, and the most effective fabrication approach have not been determined. Materials still under consideration are replicated electroformed nickel, silicon carbide produced either by vapor deposition or reaction bonding, glass or glass-like materials with an ultra-low coefficient of thermal expansion, composite materials, and thin membranes. A technology plan has been prepared and implemented to select the optimum design, material, and fabrication process for the primary mirror. The most promising technologies are being selected, and demonstration mirrors will fabricated. These mirrors will be concave, 0.5-m-diameter spheres. They will be tested interferometrically at room temperature and at cryogenic temperatures to determine and compare figure, power, smoothness, and microroughness at the two temperatures. Tests to determine structural properties, including launch survivability, will also be conducted.

At the completion of this phase, a down selection to two approaches will be made. Subscale panels will be fabricated using each approach. Each panel will be integrated with a backing structure and tested optically and mechanically. The final design, material, and fabrication technique to be used for the flight mirror will be selected based on the results of this testing.

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Biographical Sketch: Howard Hall has more than 40 years of experience in the fabrication and testing of large optical systems and components. He currently is the team lead, Optics Fabrication, in Optics Branch of the Optics and RF Division of the Astrionics Laboratory. Hall graduated from the University of Michigan with bachelor degrees in engineering mathematics and chemical engineering.